RF Design and Spectrum Analysis Methods

Communications Adaptive Design and RFI Environment (CADRE) Tool

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Outline

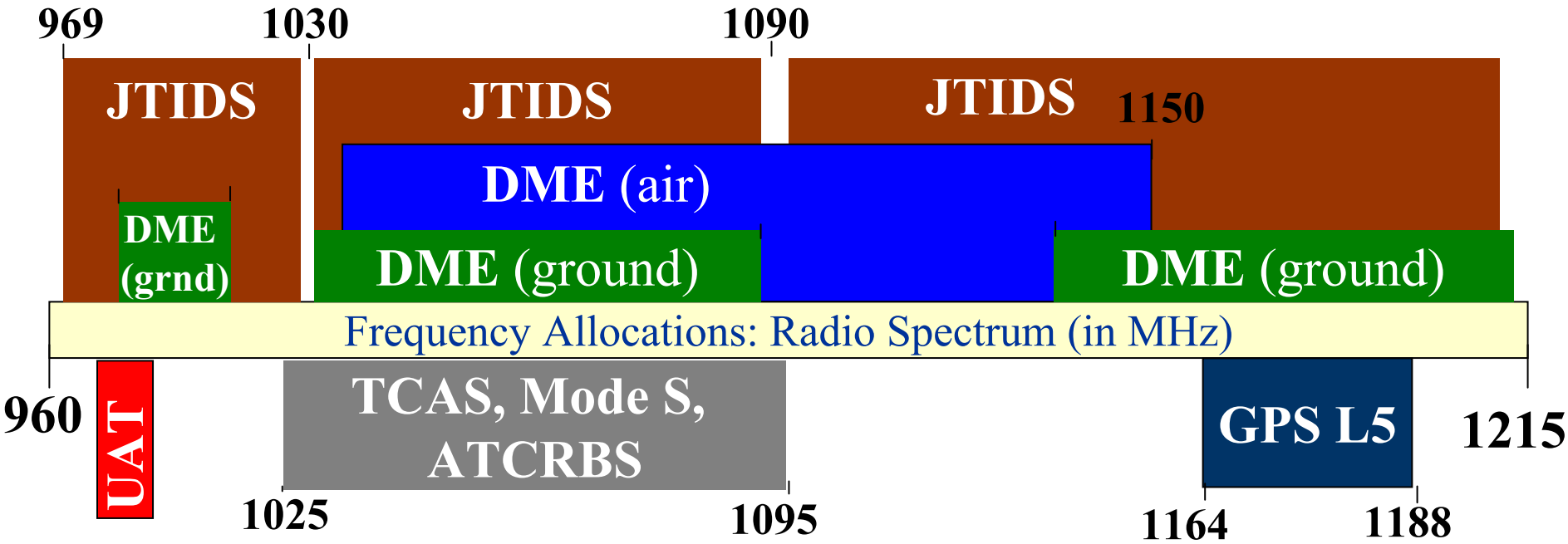
- RFI Problem
- MITRE/CAASD Solution
- CADRE Design
- Universal Access Transceiver (UAT) Case Study
- Results/Validation

Problem

- **The threat of mutual radio frequency interference (RFI) among critical systems in 960-1215 MHz band continues to increase as new systems impinging on this band are proposed**

- **Effective L-band spectrum management requires the ability to quickly and fully analyze complex interactions among existing and proposed systems to support users' coordination (e.g., FAA, DoD)**
  - **A need for high-fidelity tools to address interference issues**

L-Band Environment



Current and Potential Users of 960 - 1215 MHz Band: DME, GPS L5, JTIDS/MIDS, Mode A/S, TACAN, TCAS, UAT

Potential Source → Victim Interference Scenarios:

- **JTIDS/MIDS → UAT** (→ represents "interference to")
- **JTIDS/MIDS → GPS L5**
- **TCAS → UAT**
- **DME/TACAN → UAT**
- **DME/TACAN → GPS L5**

ATCRBS	=	**Air Traffic Control Radar Beacon System**
DME	=	**Distance Measuring Equipment**
JTIDS	=	**Joint Tactical Information Distribution System**
MIDS	=	**Multifunctional Information Distribution System**
Mode S	=	**Mode Select**
TACAN	=	**Tactical Air Navigation**
TCAS	=	**Traffic Collision and Avoidance system**
UAT	=	**Universal Access Transceiver**

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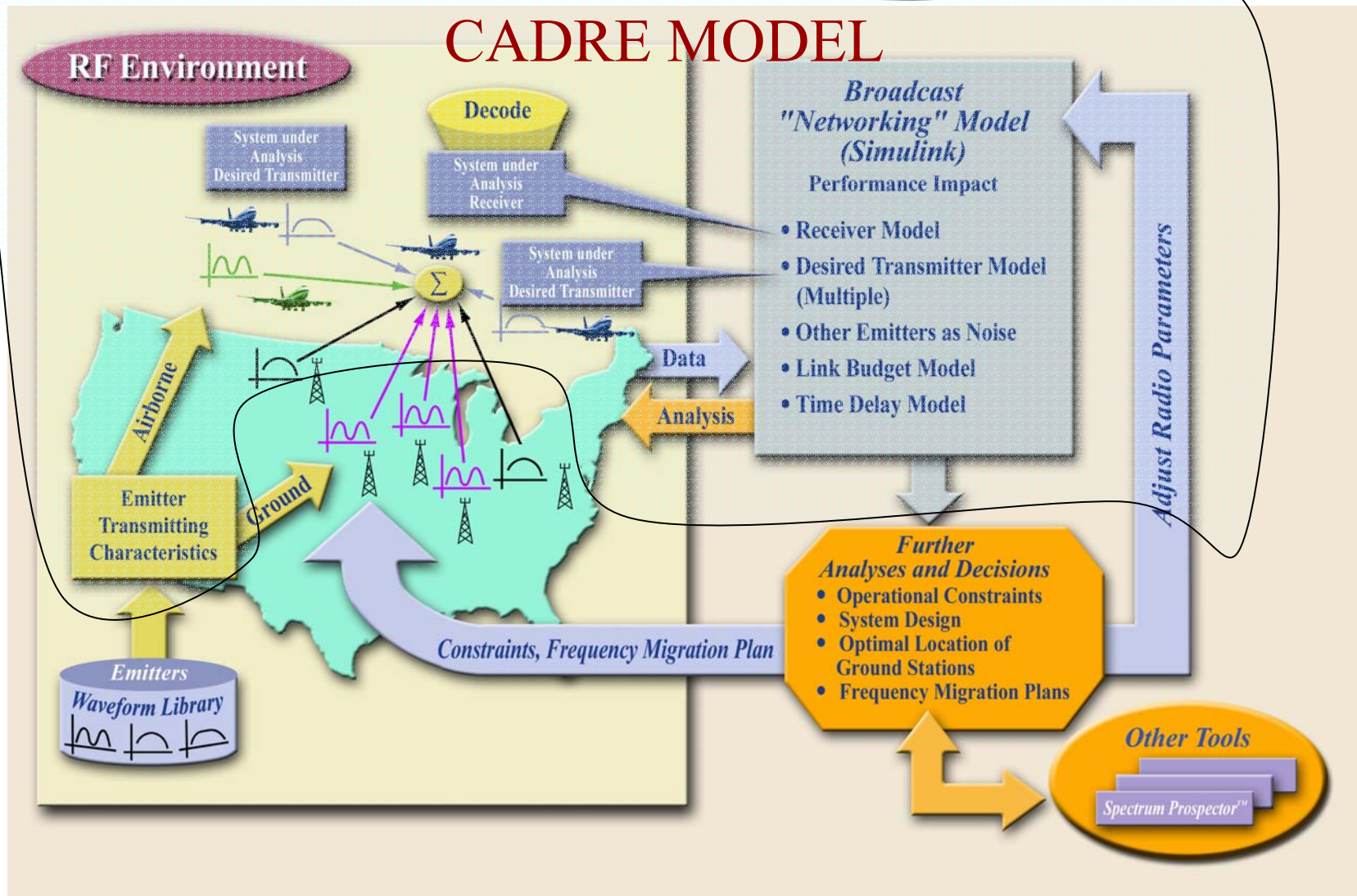
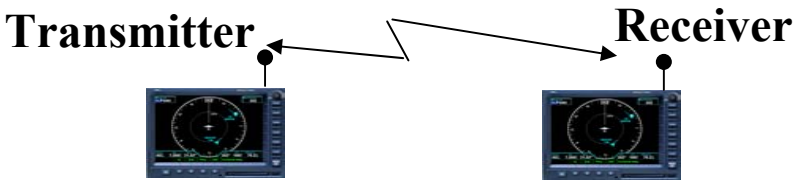
Solution: CADRE



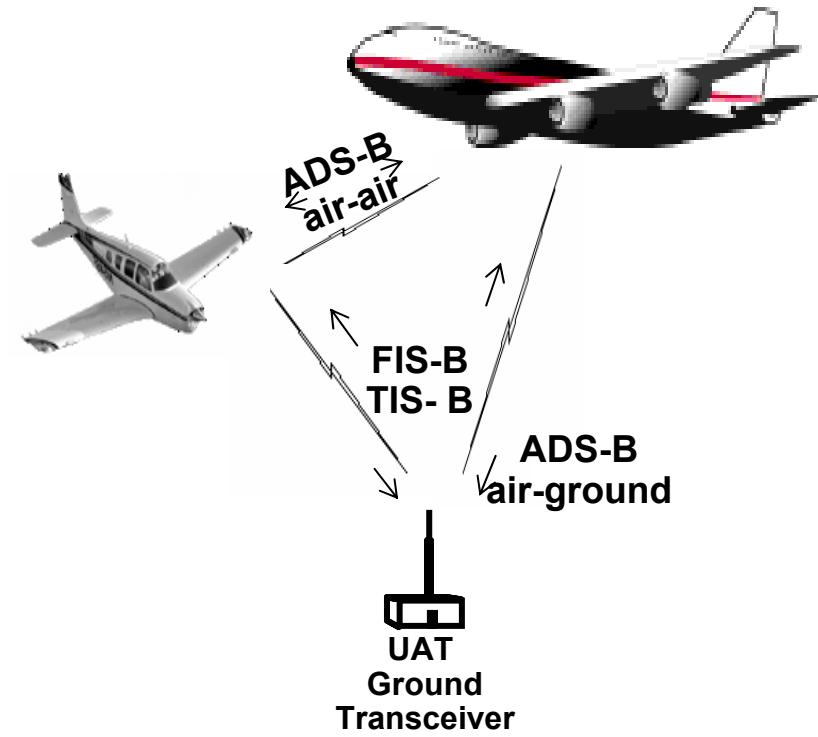
CADRE Design and UAT System

- Developed using Matlab/Simulink for UAT air-air communications
- Two main components of CADRE
  - Individual radio system model



  - Broadcast Network Environment
    Model accounts for self-interference of approximately 3,000 aircraft in LA Basin 2020 environment (JHU/APL)

- Use UAT system to validate CADRE
  - Validate results against laboratory measurements by MITRE and the Joint Spectrum Center



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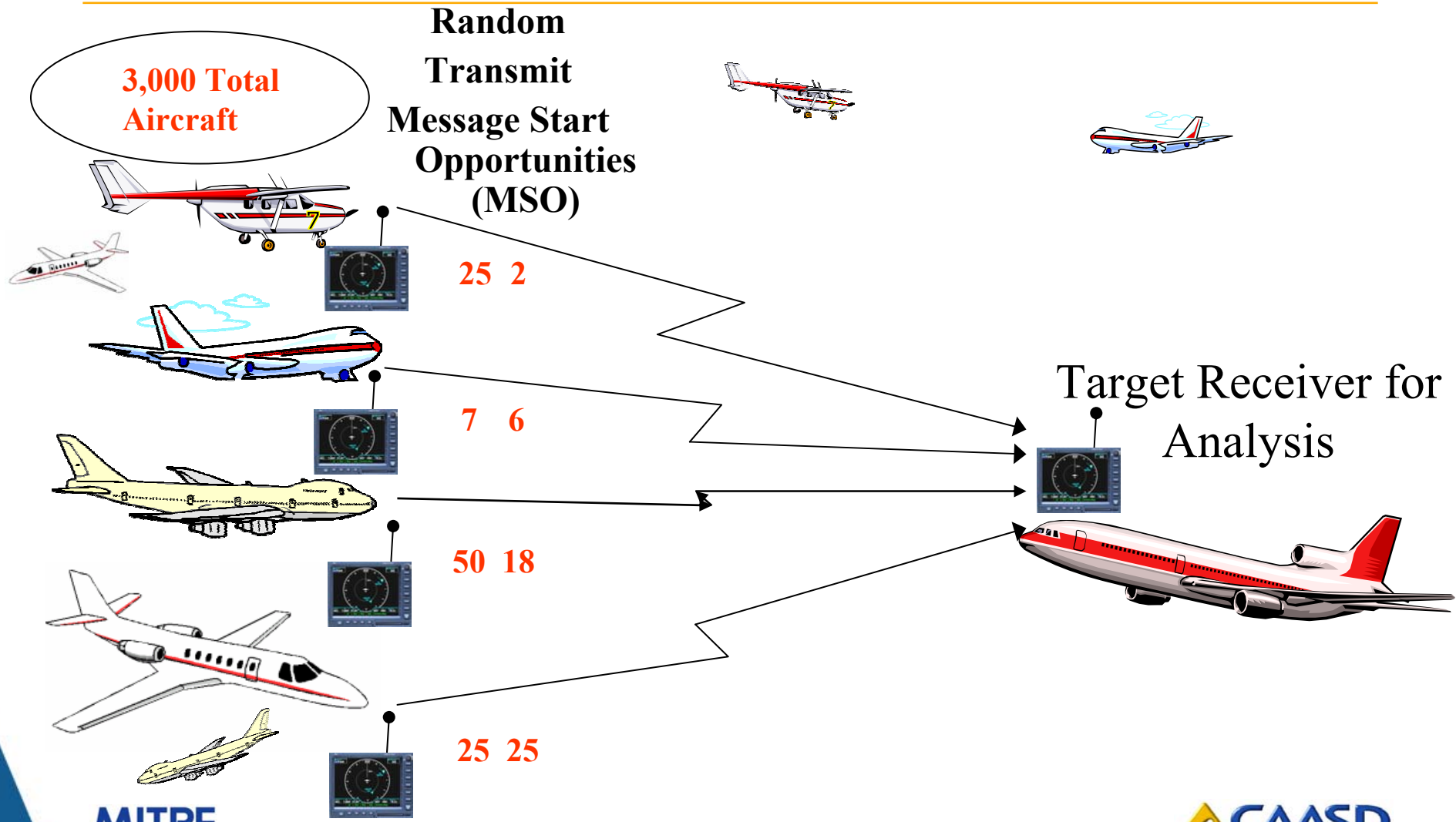
Broadcast Network Environment



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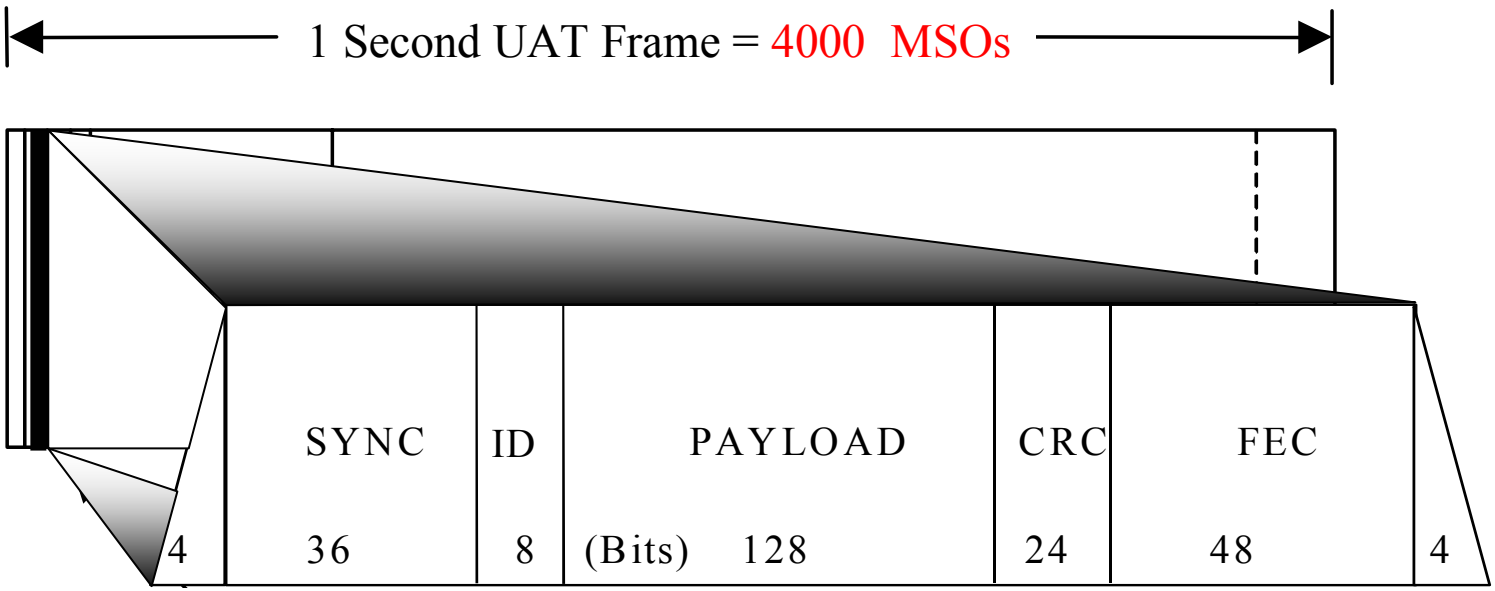
F083-B03-023

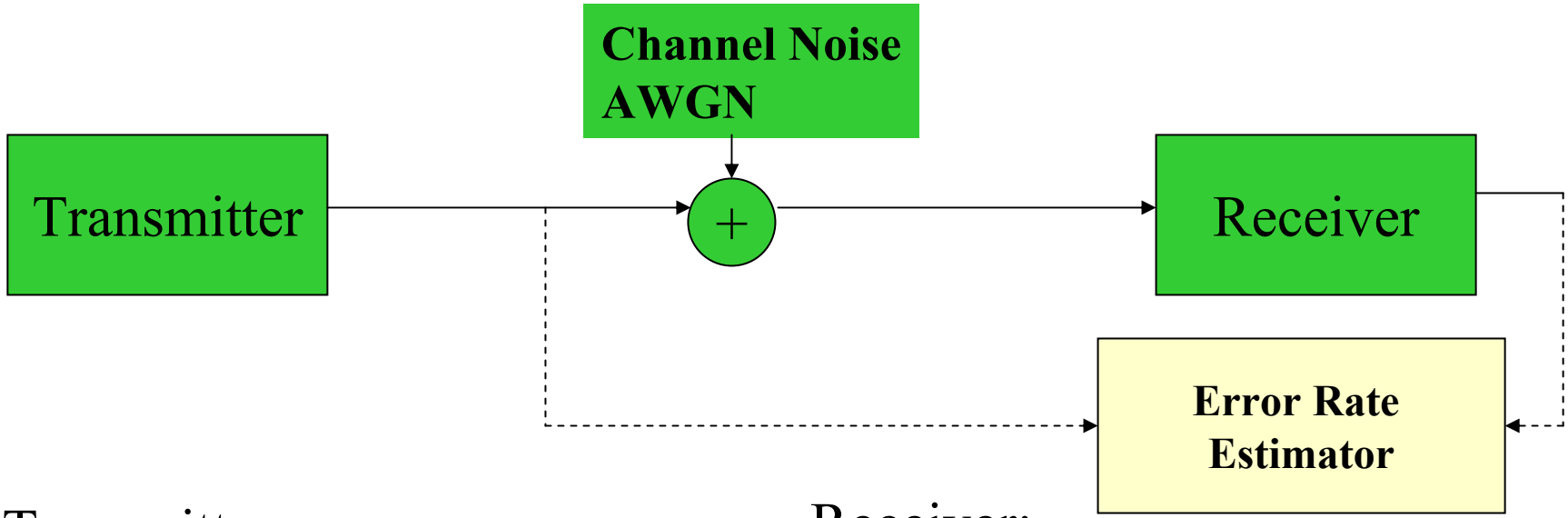
Broadcast Network Environment

- **UAT broadcast network timing is coordinated using 1 second frames**
  - **Aircraft UATs transmit at a random Message Start Opportunity (MSO) each second**



Single UAT Message per MSO

CADRE Model of UAT Radio System



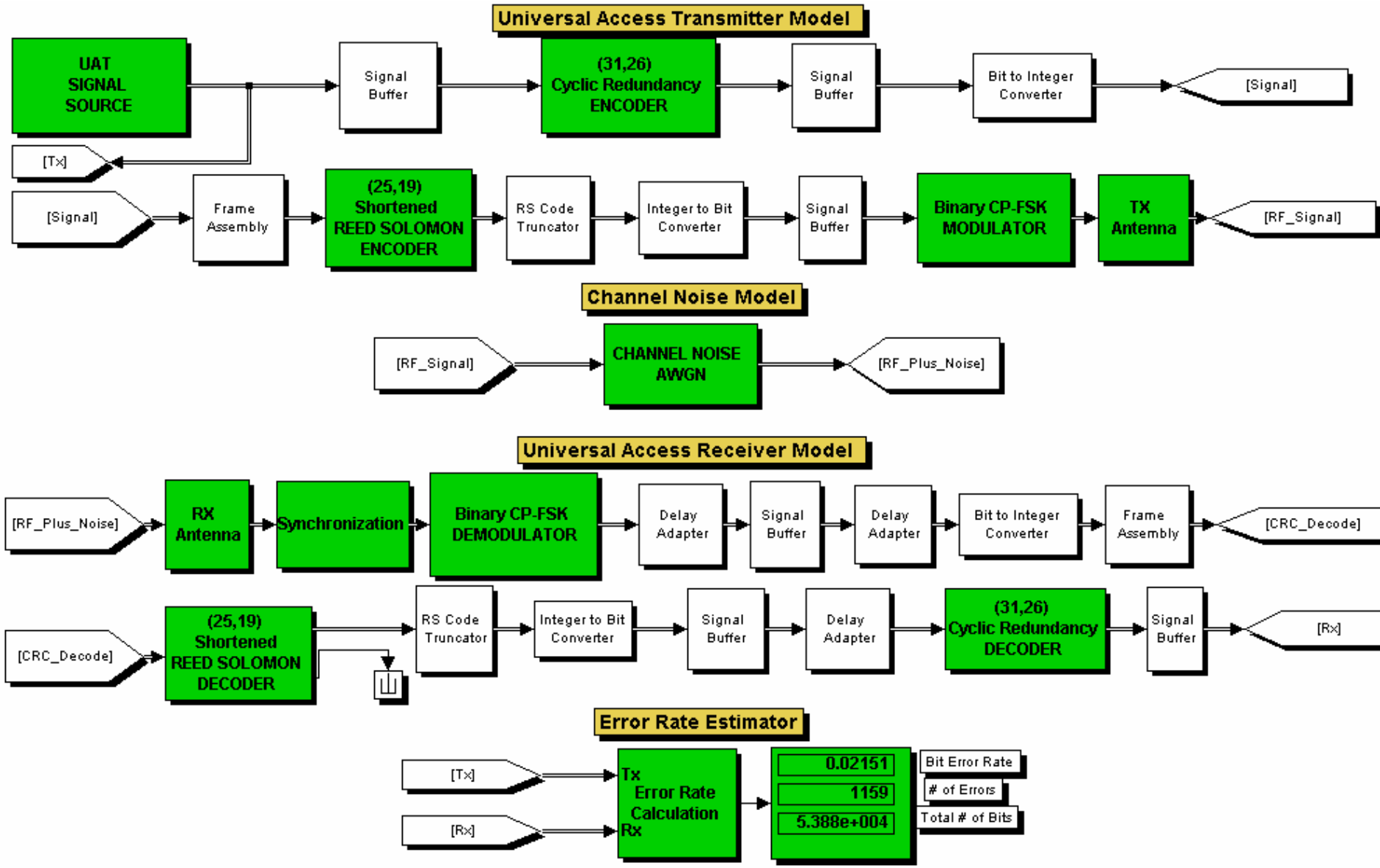
Transmitter:

- UAT Signal Source
- Cyclic Redundancy Encoder
- Reed Solomon Encoder
- Binary CP FSK Modulator
- TX Antenna

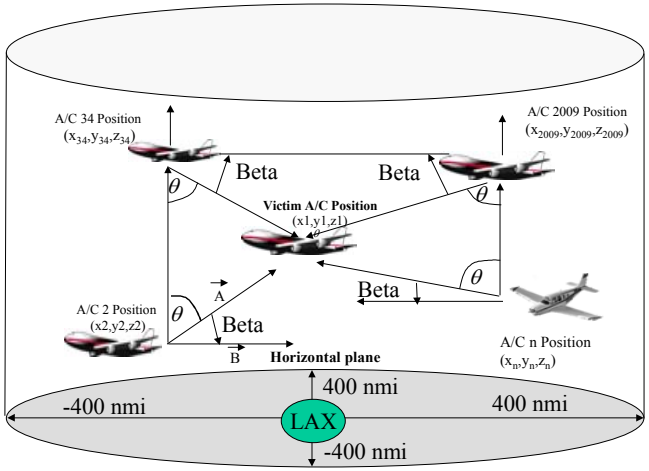
Receiver:

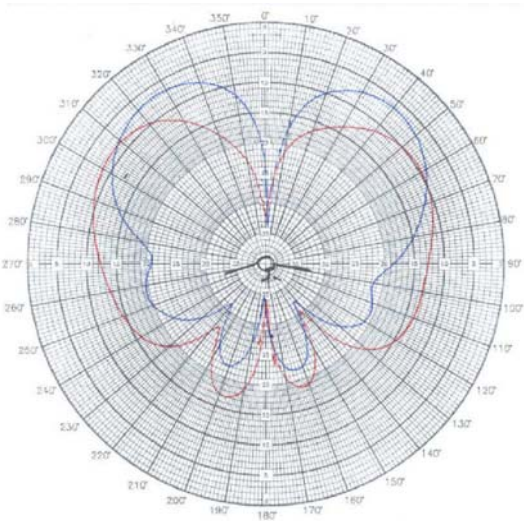
- RX Antenna
- Synchronization
- Cyclic Redundancy Decoder
- Reed Solomon Decoder
- Binary CP FSK Demodulator

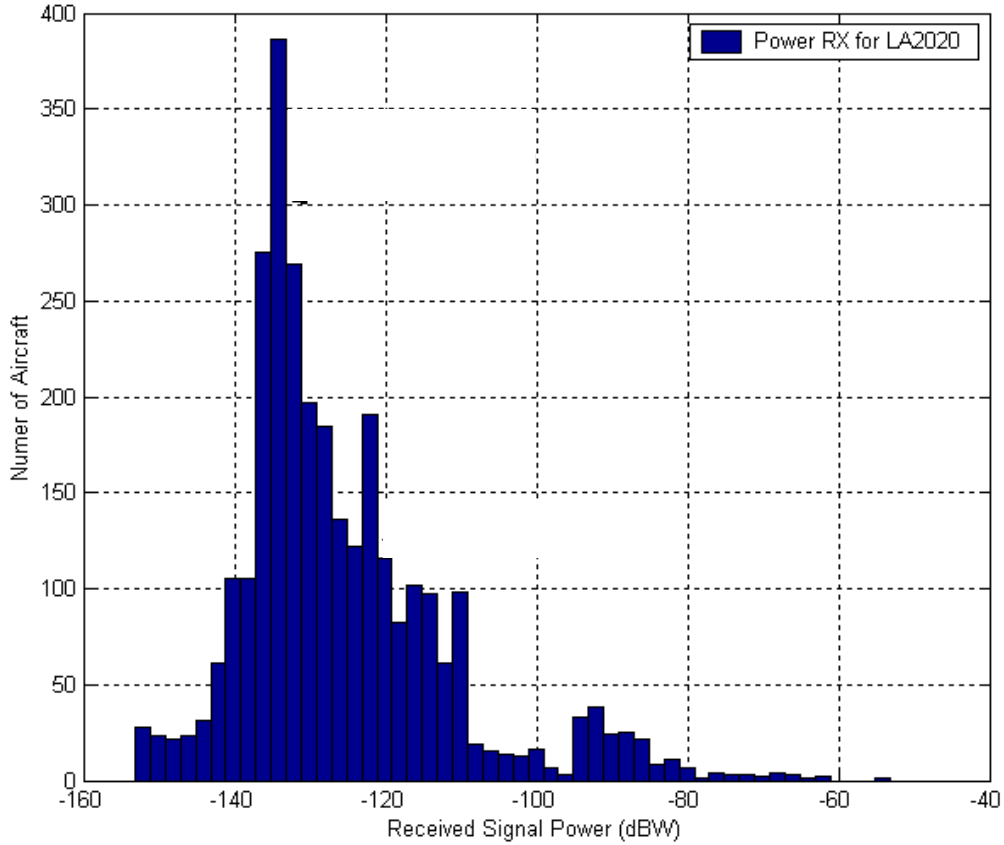
CADRE Model of UAT Radio System Model (Simulink)



UAT Case Study: CADRE Antenna Model







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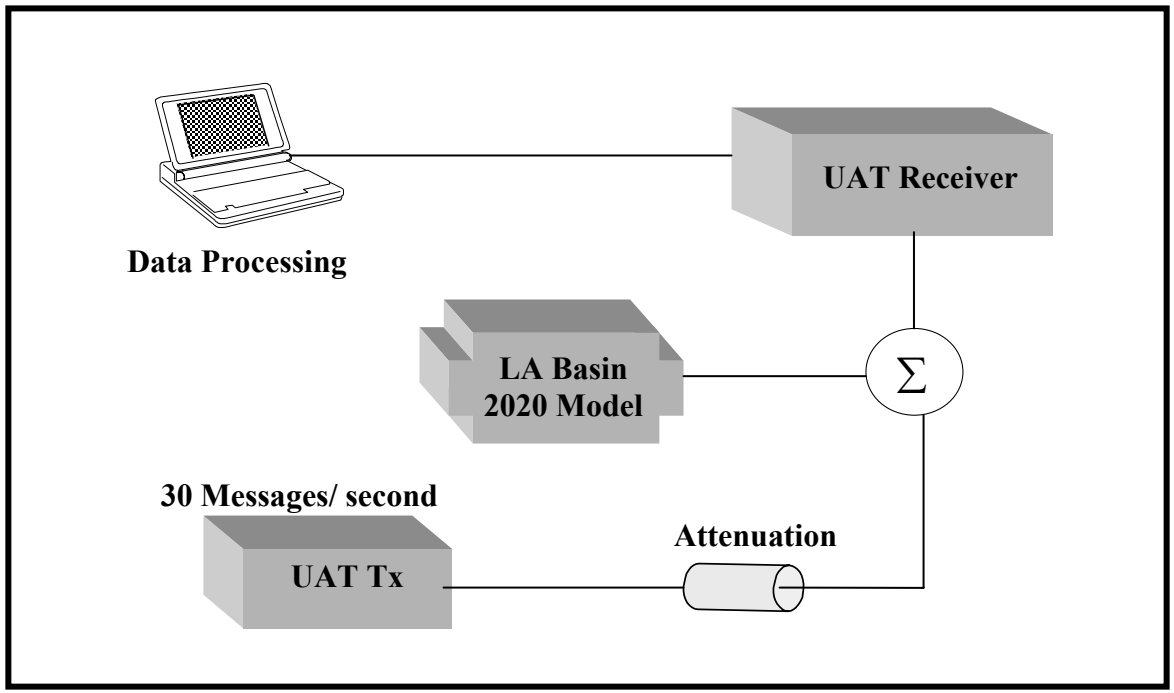
Validation Approach

- **Joint Spectrum Center Test Setup**



- **CADRE was set up to emulate this test setup**

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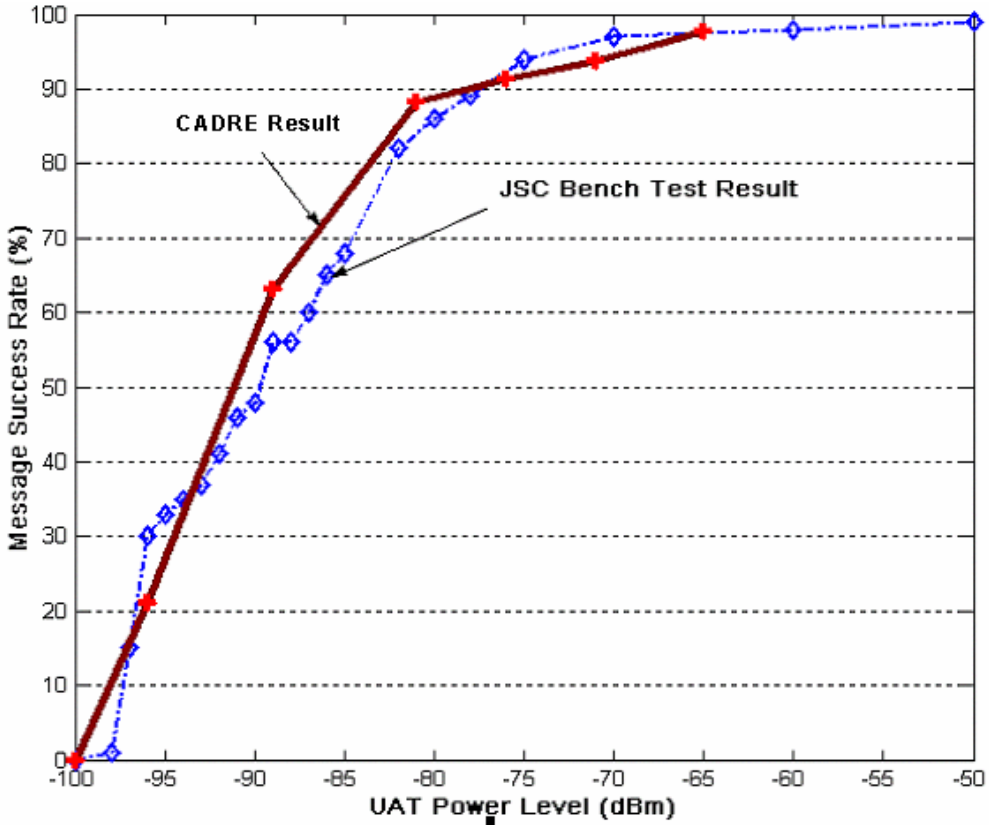
Result/Validation

JSC Test Emulation Results Comparison

Received Power vs. Message Success Rate



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Conclusion

- **CADRE accurately predicts UAT performance**
  - **Validated against measured results by the Joint Spectrum Center**
    - **Applied to worst-case scenario LA 2020 (approx. 3,000 aircraft)**
- **Methodology extensible to other systems in other frequency bands**